

Avionic Systems Division
NASA Johnson Space Center, Houston, Texas

Ubiquitous Wireless Smart Sensing & Control

Pumps & Pipes JSC: *Uniquely Houston*

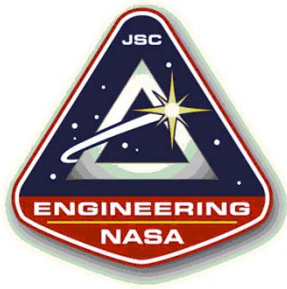
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NASA Johnson Space Center
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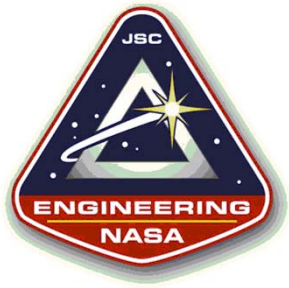
Challenge Overview:

Need new technologies to reliably and safely have humans interact within sensed environments (integrated user interfaces, physical and cognitive augmentation, training, and human-systems integration tools). Areas of focus include: radio frequency identification (RFID), motion tracking, wireless communication, wearable computing, adaptive training and decision support systems, and tele-operations. **The challenge is developing effective, low cost/mass/volume/power integrated monitoring systems to assess and control system, environmental, and operator health;** and accurately determining and controlling the physical, chemical, and biological environments of the areas and associated environmental control systems.



Challenge Update:

- **follow-up session held on May 16, 2013**
- **limited uptake so far from Pumps & Pipes partners**
 - **challenge going into “hibernation” for time being**
- **work continues on infusing industrial processing control standards into NASA applications:**
 - **Integrated Avionics, Power, and Software (iPAS) testbed**
 - **satellite test facilities (inc., ECLSS lab)**
- **work continues on adapting RFID technology to sensing**
- **partners still sought with**
 - **problems requiring wireless solutions**
 - **wireless solutions to problems**

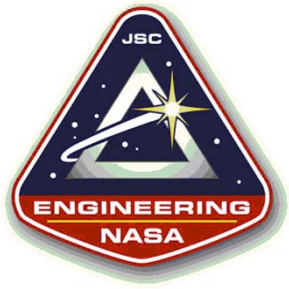


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Backup



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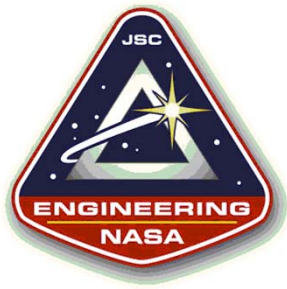
Benefits and Drawbacks Wireless Sensing

• **Benefits:**

- removing wires/connectors reduces launch weight
- sensors can be easily added, relocated during vehicle lifetime
- sensors can be placed where running wires prohibitive
- sensors can easily be relocated between vehicles (e.g., supply module to habitation module)
- radio frequency (RF) links are single-fault tolerant (at the receiver)

• **Drawbacks:**

- reliable RF comm. difficult with low-power radios due to:
 - co-existence with other wireless systems
 - time-varying multi-path interference
 - RF noise
- truly wireless comm. requires self-contained power supplies



Families of Wireless Sensing

- **Passive:**

- Radio Frequency Identification (RFID):
- most commonly used for inventory management
- uses harvested power to transmit its data
- two main variants:
 - EPCglobal (e.g., Wal-Mart inventory management)
 - Surface Acoustic Wave (SAW)

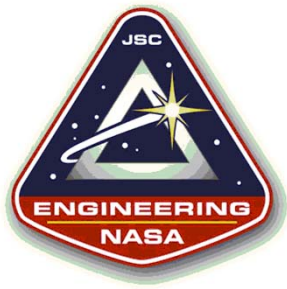
- **Active:**

- battery (or scavenged/stored) power enables transmission
- much greater bandwidth at the expense of power consumption
- many variants:
 - IEEE 802.15.4, ZigBee, ISA100.11a, WirelessHART
 - Ultra Wideband (e.g., IEEE 802.15.4a)
 - Bluetooth
 - IEEE 802.11 (e.g., Wi-Fi)



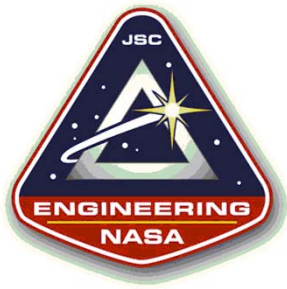
Problem Area: Maximizing Time Between Servicing

- **Must maximize ease of installation, maintenance:**
 - ideally “lick and stick”
 - cannot require significant crew time to replace batteries
 - sensor lifetime must be significant fraction of vehicle lifetime
- **Must develop full-function (e.g., routing) networks capable of deep sleeping**
 - allows increasing reliance on scavenged power
- **Must investigate pushing completely passive (e.g., RFID) techniques into sensing roles**
 - battery assisted (EPCglobal)
 - completely passive (SAW, EPCglobal)



Problem Area: Coping with Flood of Data

- **Ease of installation encourages proliferation of sensing:**
 - more producers of data encourages more consumers of data
 - publish/subscribe middleware techniques must support ad-hoc addition of both
- **Data generation may exceed long-haul link capacity:**
 - lower bandwidth and/or unreliable ground links may not accommodate all new data
 - delay/disruption tolerant networking (DTN) techniques must allow for prioritized transmission of backlogged data
- **Scalable wireless solutions must be chosen:**
 - protocols should allow steady addition of radios up to bandwidth limits
 - “infrastructure” approaches should use common networks for diverse sensing tasks



Problem Area: Overcoming Institutional Bias

- **Wireless viewed as unreliable for critical applications**
 - RF interference main issue
 - users must become comfortable with interference mitigation techniques (must continue improve)
- **Spectrum sharing viewed unfavorably**
 - dedicated bandwidth will not support wide proliferation of wireless
 - users must become comfortable with co-existence techniques (must continue improve)
- **Users reluctant to adopt low-bandwidth solutions**
 - distributed compression greatly reduces bandwidth requirements, increases system lifetimes
 - users must be convinced that processing at sensor can still fulfill system requirements